REMARKS/ARGUMENTS

This is a response to the Office Action of March 21, 2008. Reconsideration of this patent application is requested.

The undersigned grants the United States Patent and Trademark Office the right to charge Air Products' Deposit Account Number 01-0493 for any additional fees or overpayment of fees required in furtherance of this paper.

Status of the Claims

Claims 1-16 are pending in the application.

Claims 1-16 are rejected.

The Claimed Invention

The present invention relates to a process and apparatus for prereforming a feedstock.

The process comprises:

providing a reactor having a catalyst, wherein the catalyst contains an amount of nickel effective to catalyze the prereforming;

providing the feedstock in the reactor, wherein the feedstock comprises steam, *hydrogen*, and natural gas containing higher hydrocarbons along with methane;

adding an oxidant to the feedstock, wherein the oxidant provides oxygen *in an amount insufficient to partially oxidize all of the higher hydrocarbons* to a mixture of carbon monoxide and hydrogen; and

reacting the oxidant with the higher hydrocarbons in the feedstock to provide a gaseous mixture containing methane, carbon monoxide, carbon dioxide, steam and hydrogen, wherein said gaseous mixture is substantially free of higher hydrocarbons and oxygen, to thereby prereform the feedstock.

The apparatus is adapted to perform the process and comprises:

a reactor;

a feedstock source comprising steam, *hydrogen*, and natural gas containing higher hydrocarbons along with methane;

an oxidant source;

valves and pipes connecting the feedstock source, the oxidant source and the reactor; and

a nickel-containing catalyst within the reactor.

Claim Rejections – 35 USC §103

Claims 1-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hwang et al. (U.S. Pat. Pub. No. 2003/0021748) in view of Millet et al. (U.S. Pat. Pub. No. 2003/0009943).

The claimed invention requires that the feedstock comprises steam, *hydrogen*, and natural gas containing higher hydrocarbons along with methane.

Hwang et al. fail to disclose a feedstock comprising hydrogen. In [0008] of Hwang et al. it states:

> "(a) introducing a preheated inlet stream comprising a *hydrocarbon feed, water and air* into an autothermal reactor containing a layered catalyst member and contacting the stream with a member at a temperature sufficient to initiate and sustain both catalytic partial oxidation and steam reforming (for the purposes of this invention, the term "water" will be understood to encompass "steam");" (*emphasis added*)

The preheated inlet stream of Hwang et al. does not comprise hydrogen. Hydrogen is not a hydrocarbon.

According to the present invention, hydrogen is generally present in the feed stream from the desulfurization step (see [0030]).

Hwang et al. does not have a desulfurization step. See paragraph [0029] of Hwang et al. where it states that "The catalyst should operate effectively in the presence of carbon monoxide, olefins, aromatic hydrocarbons and sulfur compounds." Later in the same paragraph it states: "The catalyst must be able to resist poisoning from such common

poisons such as sulfur and halogen compounds." Therefore Hwang et al. would not have hydrogen present in the feed left over from a desulfurization step.

Likewise, Millet et al. fail to disclose a feedstock comprising hydrogen. In [0055] of Millet et al. it states:

> "The basic principle of this invention is to do partial oxidation of methane or LPG (natural gas usually contains mostly CH_4), and a percentage of CO_2, N_2 and heavier hydrocarbons (propane, butane). *Natural gas or LPG is used for the purpose of this invention*, but from a chemical point of view, the CH_4 propane and butane molecules are partially oxidized) in order to obtain a hydrogen/carbon monoxide mixture according to reaction (2) below:
>
> $$CH4 + \tfrac{1}{2} O2 \rightarrow CO + 2H2 \quad (2)$$" (*emphasis added*)

Millet et al., like Hwang et al., relates to a process using catalytic partial oxidation (see abstract of each). Millet et al., like Hwang et al. do not disclose a desulfurization step. Therefore, Millet et al. would not have hydrogen present in the feed left over from a desulfurization step.

The claimed process requires that the oxidant added to the feedstock provides oxygen *in an amount insufficient to partially oxidize all of the* ***higher*** *hydrocarbons* to a mixture of carbon monoxide and hydrogen.

The oxygen to carbon ratio (O_2/C) provided in the present invention is based on the higher hydrocarbons concentration, which excludes methane.

Hwang et al., paragraph [0016] states:

> The hydrocarbon feed may consist of C_5 and heavier hydrocarbons, but is preferably a normally gaseous or readily vaporizable hydrocarbon such as a C_1-C_4 alkane, e.g., methane, propane, butane, etc. The amounts of the hydrocarbon feed, water and air in the inlet stream introduced into the autothermal reactor are typically controlled to maintain a water to carbon ratio of at least about 0.3:1 and an *oxygen to carbon ratio of from about 0.2 to 0.7:1*." (*emphasis added*)

By contrast, in Hwang et al., the oxygen to carbon ratio (O_2/C) provided is based on the *total* carbon in the hydrocarbon feed, including methane.

Applicants will illustrate that oxygen an amount insufficient to partially oxidize all of the higher hydrocarbons to a mixture of carbon monoxide and hydrogen is outside the oxygen to carbon ratio (O_2/C) range 0.2 to 0.7:1.

In paragraph [0029] of the present application, the concentration range of various species in natural gas is given. The calculation will used here will consider a basis of 100 moles. In the calculation of the oxygen to carbon ratio (O_2/C) for an amount insufficient to partially oxidize all of the higher hydrocarbons, the highest value is calculated for a higher concentration of higher hydrocarbons. Then, to calculate the highest value of the oxygen to carbon ratio (O_2/C), the lowest concentration of methane (85%) in the natural gas should be used. It is stated that up to 2% butane may be present, and up to 5% propane may be present. The balance, for ethane, to make 100%, would then be 8%. The basis is summarized below in the table.

Species	CH_4	C_2H_6	C_3H_8	C_4H_{10}
Moles	85	8	5	2

The moles of O_2 to partially oxidize C_2H_6 to CO and H_2 is 8 moles:

$$8C_2H_6 + 8O_2 \rightarrow 16CO + 24H_2 .$$

The moles of O_2 to partially oxidize C_3H_8 to CO and H_2 is 7.5 moles:

$$5C_3H_8 + 7.5O_2 \rightarrow 15CO + 20H_2 .$$

The moles of O_2 to partially oxidize C_4H_{10} to CO and H_2 is 4 moles:

$$2C_4H_{10} + 4O_2 \rightarrow 8CO + 10H_2 .$$

The total moles of O_2 is 8+7.5+4= 19.5 moles O_2.

The total moles of carbon is 125 moles C; 85 from CH_4, 16 from C_2H_6, 15 from C_3H_8, and 8 from C_4H_{10}.

For this example, the oxygen to carbon ratio (O_2/C) is then 0.16 (19.5/125). Then for any natural gas compositions that can be envisaged, the oxygen to carbon ratio (O_2/C) according

to the invention is less than 0.16, which is less than the value of 0.2 disclosed by Hwang et al.

Therefore Hwang et al. does not disclose the claimed limitation:

> adding an oxidant to the feedstock, wherein the oxidant provides oxygen *in an amount insufficient to partially oxidize all of the higher hydrocarbons* to a mixture of carbon monoxide and hydrogen.

Millet et al. disclose in paragraph [0091] that the CH_4/O_2 ratio is between 1 and 2.5. This is equivalent to stating that the oxygen to carbon ratio (O_2/C) is 0.4 to 1 for pure methane.

Therefore Millet et al. also does not disclose the claimed limitation:

> adding an oxidant to the feedstock, wherein the oxidant provides oxygen *in an amount insufficient to partially oxidize all of the higher hydrocarbons* to a mixture of carbon monoxide and hydrogen.

According to § 2143.03 of the MPEP, to establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art.

Applicants respectfully submit that the Examiner has failed to establish a *prima facie* obviousness rejection of independent Claims 1 and 16 in view of Hwang et al. and Millet et al. since neither disclose H_2 in the feedstock and neither disclose providing oxygen in an amount insufficient to partially oxidize all of the higher hydrocarbons to a mixture of carbon monoxide and hydrogen.

Also according to § 2143.03 of the MPEP, if an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. Claims 2-15 depend from independent claim 1 and therefore includes all of the limitations of claim 1. Consequently, the Examiner has failed to establish a prima facie obviousness rejection of claims 2-15.

Applicants respectfully request the Examiner to withdraw the rejection of claims 1-16.

Prior Art of Record, Not Relied Upon by Examiner

Applicants acknowledge that Park et al., U.S. Pat. Appl. No. 2004/0142817 has been made of record for disclosing a nickel catalyst for steam-oxygen reforming.

SUMMARY

Applicants believe that the foregoing constitutes a complete and full response to the Action of record. Applicants respectfully submit that this application is now in condition for allowance. Accordingly, an indication of allowability and an early Notice of Allowance are respectfully requested.

The undersigned grants the United States Patent and Trademark Office the right to charge Deposit Account Number 01-0493 in the name of Air Products and Chemicals, Inc. for any fees required and any additional fees or overpayment of fees required in furtherance of this paper.

For all of the foregoing reasons, Applicant respectfully requests withdrawal of the rejection of Claims 1 through 16, inclusive, and earnestly solicit a Notice of Allowance thereof.

Respectfully submitted,

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